Most greenhouses are erected to produce plants during the off-season; therefore, they must provide a desirable plant environment. Correct location and orientation of the house are of paramount importance in providing ideal environmental conditions. Since location can also influence the heating cost, labor utilization, and disease factors, economic success may also depend on the site selection.

Recommendations for locating and orientating your greenhouse are given in this publication. The following specifications are the ideal ones; however, some builders may not be able to follow each suggestion given, depending on individual limitations of their houses. For example, houses used for display and sales purposes are often connected to existing buildings; therefore, they may have to sacrifice some of those factors described for production-type greenhouses. Bench culture or similar production practices may also justify deviation from some of the standard requirements. To provide optimum plant response and teaching effectiveness, however, the authors believe recommendations should be followed as nearly as possible in building all houses used for educational purposes.

LOCATION OF THE GREENHOUSE

Sunlight

Sunlight provides energy for plant growth, and is generally the limiting factor in greenhouses. When planning the construction, give primary consideration to obtaining maximum sunlight exposure during those "short" days of mid-winter when the sun is lowest in the sky. Maximum sun altitude (angle of sun above earth's horizon) occurs at noon and varies from a high on June 21 to a low on December 21. Solar altitudes for selected latitudes (distance measured in degrees north and south from the equator) and times of day are given in Table 1. The latitude of 42° would correspond to Detroit, Michigan; 38° to Lexington, Kentucky; 34° to Little Rock, Arkansas; and 30° to New Orleans, Louisiana. At solar noon, the sun is located due south. This means that the building site should preferably have an open southern exposure. If the land slopes, it should ideally slope to the south.

Do not build near large trees, buildings, or other obstructions which will shade the building. Figure 1 gives the ratio of shadow length and height obstructions for selected solar altitudes. To determine how far away an obstruction must be to prevent a shadow on the greenhouse, multiply these ratios by the obstruction height. As a general rule, the greenhouse should be located at least 2.5 times the height of the object away from it, in either the east, west, or south direction. Even objects this tall will cast long shadows in the early morning when the sun is particularly low in the sky.

Soil

When plants are to be grown in the soil covered by the greenhouse, select a site where a deep, good draining, fertile soil is available. A sandy loam or silt loam type soil is preferred. Avoid top soil below which a tight hardpan is present. Although organic matter and artificial types of conditioners can be added, problems are reduced if a site with good natural soil
If you question the degree of danger, grow selected plants in samples of the soil to determine if any detectable injury occurs. Noxious weed seeds can also be a problem, but generally proper sterilization methods will kill most weed seeds.

Where a good soil is not available for the location of the greenhouse, consider cultural techniques using artificial media such as peat and vermiculite.

**Drainage**

Select a site that is level and well drained to reduce problems with salt build-up and insufficient soil aeration. A high water table may result in saturation of the soil and prohibit effective use of the greenhouse. Ground water which flows into the house may carry soil diseases. If necessary, tile drain the area enclosed by the greenhouse. Tile lines within the greenhouse can also be used for steam sterilization if properly placed in the soil.

Ground beds should be nearly level. If they slope in any direction, water will tend to concentrate in the low areas, accentuating any problems of poor drainage. Slopes within the greenhouse also allow hot air to rise and cold air to settle, creating added problems for the environmental system to overcome. A greenhouse in a low, damp area could be subject to higher humidities and dampness which accentuate leaf mold, diseases, etc.

**Sheltered Area**

Although obtaining maximum sunlight should have first consideration, placing the greenhouse in a sheltered area will reduce wind-induced heat losses. For example, a wind barrier north of the greenhouse may materially reduce heating costs; yet it would have little effect on the light received. Trees are helpful in preventing winter heat loss, but deciduous trees which lose their leaves in the winter are not effective when the heat loss potential is greatest.

In areas of heavy winter snowfall where snowdrifts occur, wind and snow breaks need to be 100 feet or more away from the greenhouse to reduce major drifts.

**Utilities**

A greenhouse requires a number of utilities, notably electricity, water, and an energy source for heat.

*Electricity:* The electric service for ventilation alone will require approximately 4 to 6 kilowatts for a 1/4-acre range. For a small hobby-sized house, connected loads of up to 1 to 2 kilowatts are not unusual. If lights are used for photoperiod control or supplemental lighting, the electric load will increase significantly. Normally the electric power companies will willingly supply the necessary service; however, the grower should attempt to anticipate his intended electric usage and provide sufficient entrance capacity to allow for full electric utilization.
Water: A reliable supply of clean water is mandatory. A water requirement of up to 1/3 gallon per square foot per day may be needed. Depending upon the soil type, up to 1 gallon of water per square foot may be put on the soil at one time. Water from ponds has the disadvantage of being cold during the winter. If this water is used directly for irrigation, plant roots may chill, causing a detrimental effect. Pump water from such sources into a large storage tank within a heated portion of the greenhouse or house so that its temperature will approach that of the plants. Also, with ponds, the possibility of chemical pollution exists unless the surrounding drainage area is carefully controlled.

Energy Source: The availability of an inexpensive energy source is often one of the most important factors in determining where to build a greenhouse range. Natural gas is a widely preferred fuel because of its clean performance, low maintenance, and relatively low cost. Not only is it one of the lower cost fuels, but gas heating equipment is generally among the least expensive for initial cost, annual maintenance, and operating costs. LP Gas, fuel oil, and coal are alternate sources of fuel and can be transported to greenhouse locations that are not close to gas lines.

Electric energy is becoming more competitive in many areas for greenhouse heating where the above fuels are in short supply or rapidly rising in costs. Hot-air resistance heating units can be used in hobby or individual houses. Central hot-water furnaces could be more suitable for larger combined houses of 1/4 acre or more. Since heating costs can be as much as two-thirds of the production cost for some crops, select a location and energy source carefully for future availability and economy.

Emergency Power

Standby emergency power equipment sized for electrical support of heating equipment, air circulation, and minimum ventilation is vital when winter storms disrupt local service for long periods (2 hours or more).

Alarm System

The consequences of a heating system failure during freezing temperatures can be catastrophic. An alarm system which is independent of the electrical service should, therefore, be provided. Place the alarm bell in a residence or location where people are normally present.

Convenience

Locate the greenhouse near your place of residence, if possible, or where a caretaker can be housed nearby. This will prove convenient for security and will facilitate care during weekends or holiday periods. If the ventilation and watering systems are not fully automatic, operator care will also be mandatory during sunny periods. Should a heating failure occur, corrective action must be prompt.

ORIENTATION OF THE GREENHOUSE

Light Availability and Shading Effects

Orientation of the greenhouse for maximum light availability is also an important consideration. Manbeck and Aldrich ("Analytical Determination of Direct Visible Solar Energy Transmitted by Rigid Plastic Greenhouses," Trans. of ASAE, 1967) report that an east-west orientation (i.e., the ridge of the house running east and west) is preferable in the winter for northern locations (above 40° to 45° latitude). At other times of the year for the northern regions and at all times for the southern regions, a north-south orientation of the ridge is preferable. Since light is most critical during mid-winter, growers in the northern latitudes (i.e., 40°N or greater) should use the east-west orientation for single-width houses if possible. With east-west orientation, however, a problem is encountered with ridge and furrow houses. A definite shadow line develops within the houses due to the north sloping roof sections and the gutter between sections of the house. This shadow effect is usually sufficient to result in reduced plant growth in the region of the house affected. Depending upon the width of span, the shadow area can be 10 percent or more of the house space. Although shadows occur within north-south oriented ridge and furrow houses, the shadows move across the floor of the house as the day progresses and noticeable reduction in growth in one region of the greenhouse is not normally apparent.

Environmental Equipment

Ventilation, cooling and heating systems are noticeably affected by the way the greenhouse is oriented and the equipment installed.

Ventilation: Ventilation air should not have to move more than 120 to 150 feet across the house between entrance and exit. Design and install fan ventilation systems so that air moves with (in the direction of) prevailing summer winds rather than against them. This procedure will eliminate opposing air forces which decrease the air flow rate by 10 percent or more. Usually, you should install exhaust fans in the leeward end of the greenhouse and fresh air inlet shutters in the windward end. However, sometimes a sidewall fan location in the leeward side and fresh air inlets on each end are best for certain houses.

Cooling System: When pad cooling is used, locate pads on the north wall (end or side) of the greenhouse(s) to prevent shading. For best cooling effectiveness, air should
not travel over 100 feet between pads and the exhaust fans. For long houses, over 100 feet in length, locate the bank of pads in a sidewall at the center of the house with fans in each end. (NOTE: A water supply of approximately 1 to 2 gallons per minute per 100 square feet of pads is generally required. Also, 100 square feet of pad areas per 1,200 to 1,500 square feet of greenhouse floor area is typical. Obtain more detailed information on pad cooling before making a decision to purchase.)

**Heating System:** The greenhouse heating system should provide adequate heat supply and distribution throughout the house for environmental uniformity. Consistent heat supply is especially important toward the northwest portion of glass houses or those with sizeable cold air leakage and infiltration.

### SITE LAYOUT

#### Grade and Fill

Prior to erecting the greenhouse, grade and fill those areas where changes are needed to level the site, establish drainage, roads, parking, etc. If you plan to practice soil culture, remember that poor existing soil must be removed and replaced by 12 inches or more of good topsoil. Grade and fill the subsoil material to requirements, then replace the top soil without compaction. Any subsurface tiling or utility lines can be placed during these operations.

#### Transportation and Parking

When selecting the site, try to locate near a good road so that materials can be conveniently moved to and from the greenhouse. Sufficient room for turning and parking vehicles is desirable for greenhouses of commercial size, especially when bedding plants and flowers are sold on the premises. Allow 18 feet for head-in parking spaces and 26-30 feet clearance for back-out and turning. Make any curves or turns with 18-20 foot inside radius.

#### Headhouses

Place headhouses on the north side of the greenhouse to avoid shading a portion of the house. Attachment to the greenhouse or a connecting passageway makes work, handling, and greenhouse operations more convenient but complicates construction techniques to attach without leaks and other maintenance problems. Processing facilities, cold storage rooms, and other such facilities should be adequately incorporated into the ultimate layout.

**Expansion**

When building, always keep future expansion in mind. Most successful ranges are expanded several times after the first house or small range area is constructed.

![Figure 2. Typical greenhouse range layout on a level but well drained, southerly exposed site.](image)

**SUMMARY**

Important points to remember are:

- Orient and locate the house for maximum sunlight. In southern latitudes, the ridge should run north-south, and in northern latitudes, east-west.
- Avoid placing the house near objects east, west, or south which will shade the house.
- Place in an area sheltered from northerly and north-westerly high winds if possible.
- Locate on a deep good soil which is well drained and where surface water does not run into the house.
- Avoid sloping beds or floors in the greenhouse. Locate the greenhouse near adequate and reliable sources of utilities—electricity, water and gas.
- Provide good access roads, parking, and turnaround area.
- Position headhouses or supporting facilities on the north side.
- Arrange initial construction so that the range can be expanded.

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